

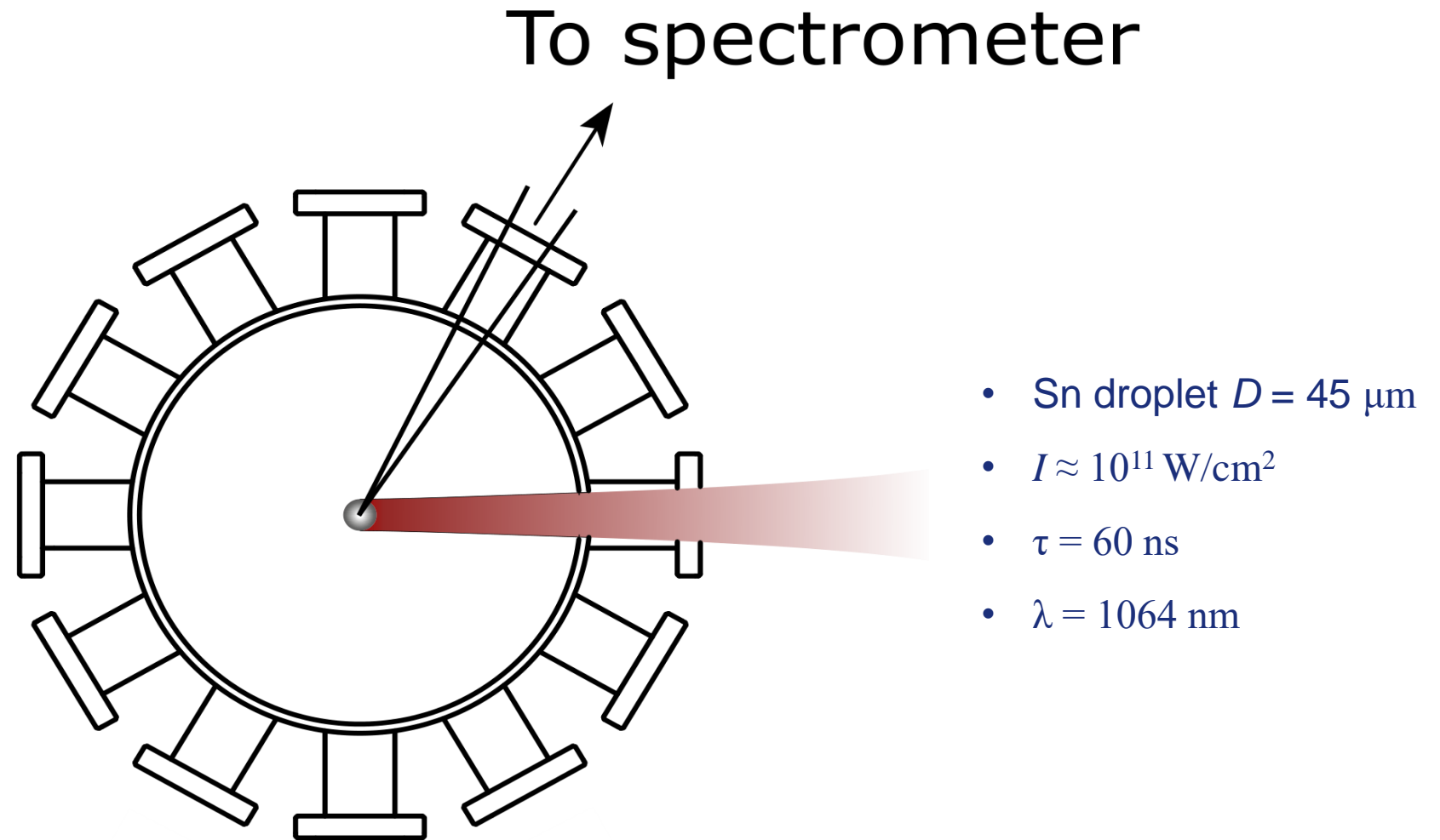
# Short-wavelength out-of-band EUV emission from Sn laser-produced plasma

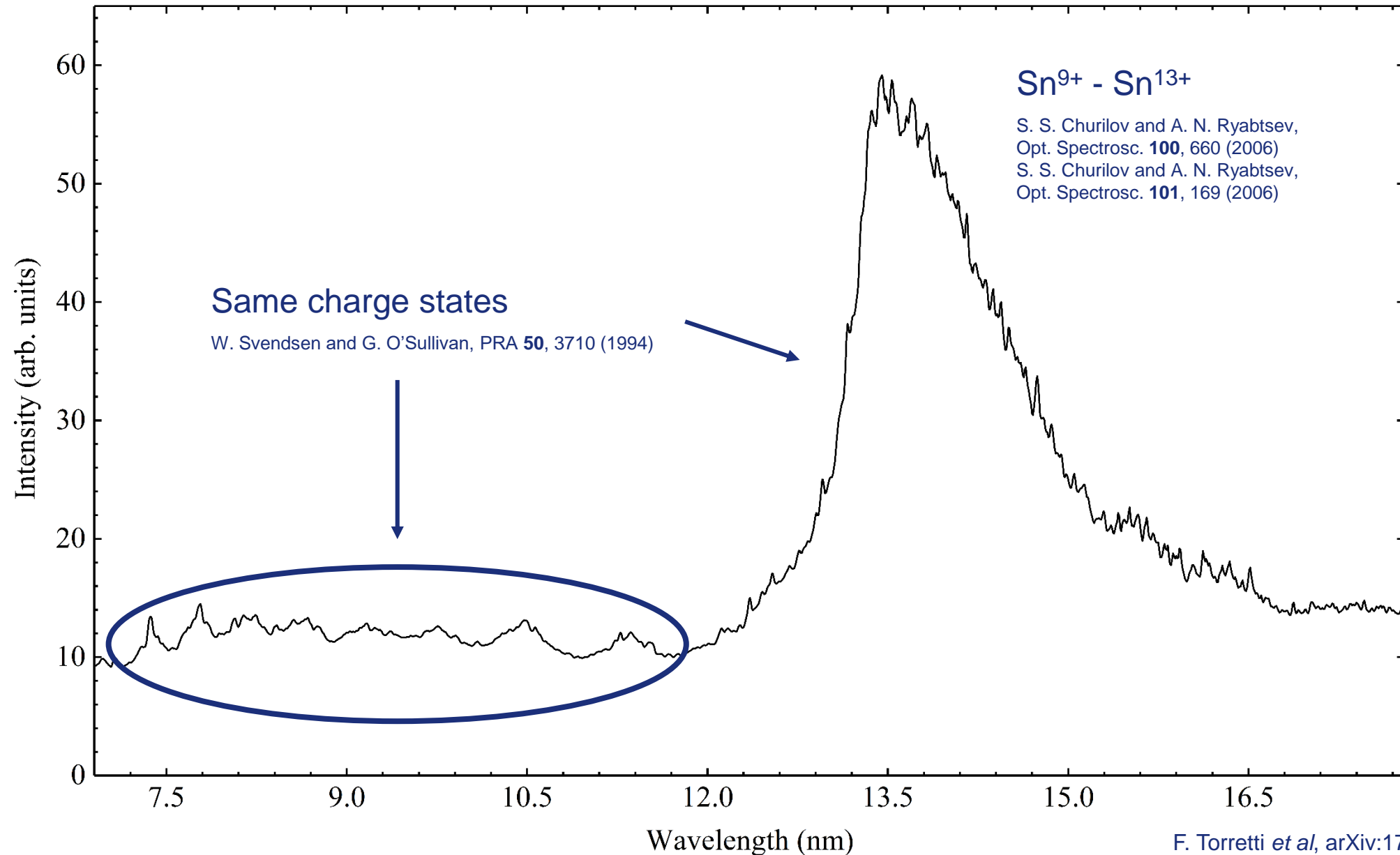
F Torretti, R Schupp, D Kurilovich, A Bayerle, J Scheers, W  
Ubachs, R Hoekstra, and O O Versolato

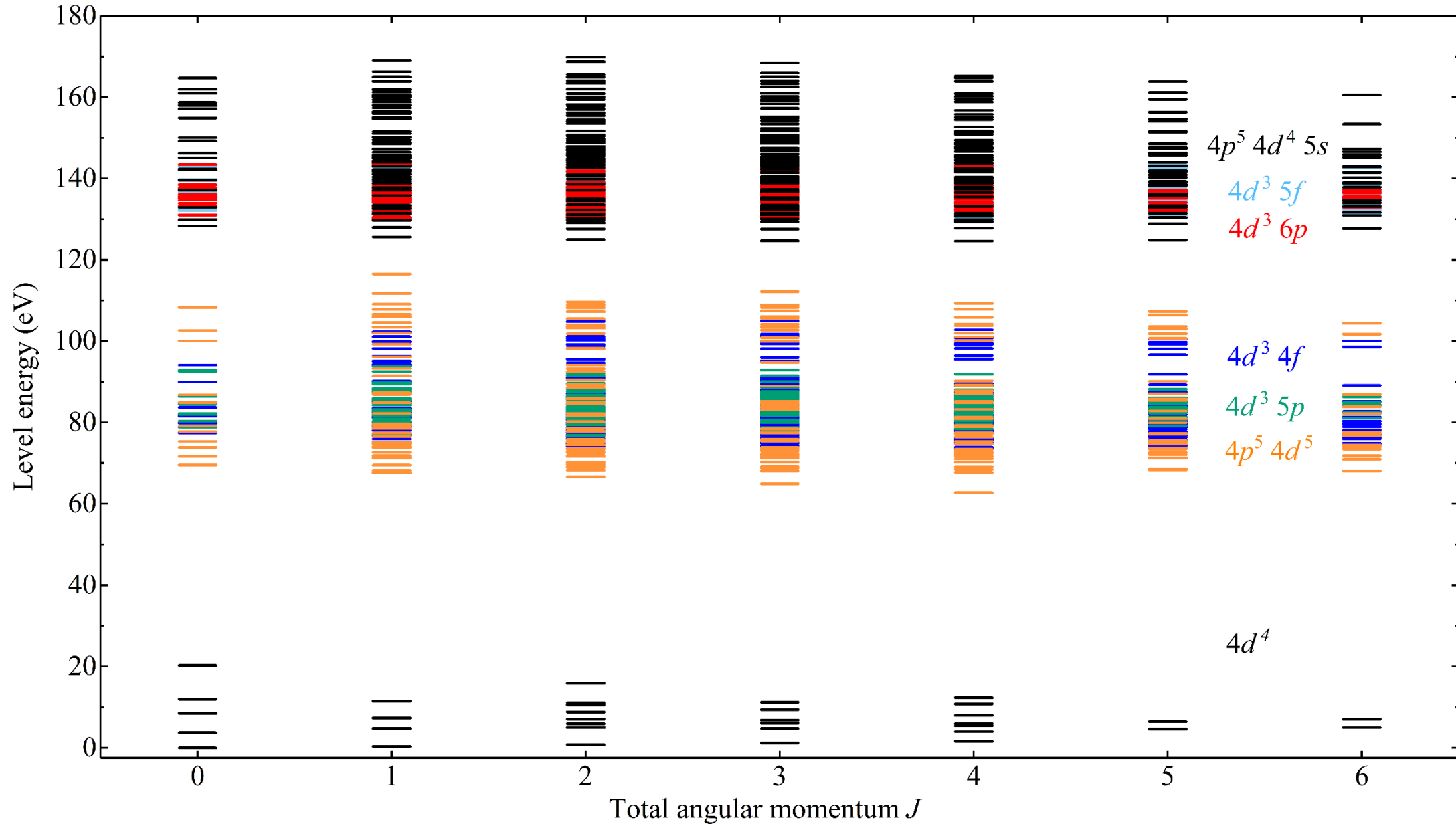
EUV Plasma Processes

Advanced Research Center for Nanolithography



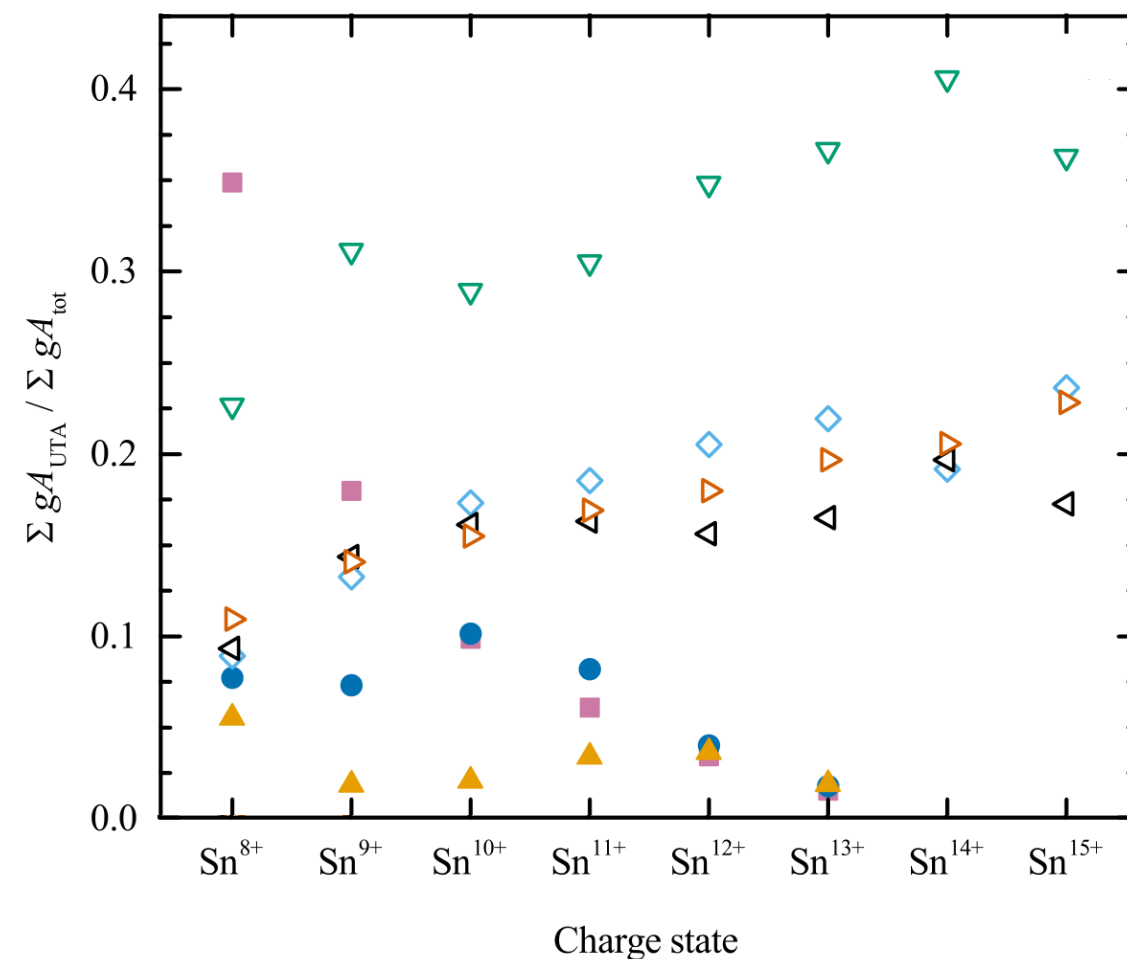
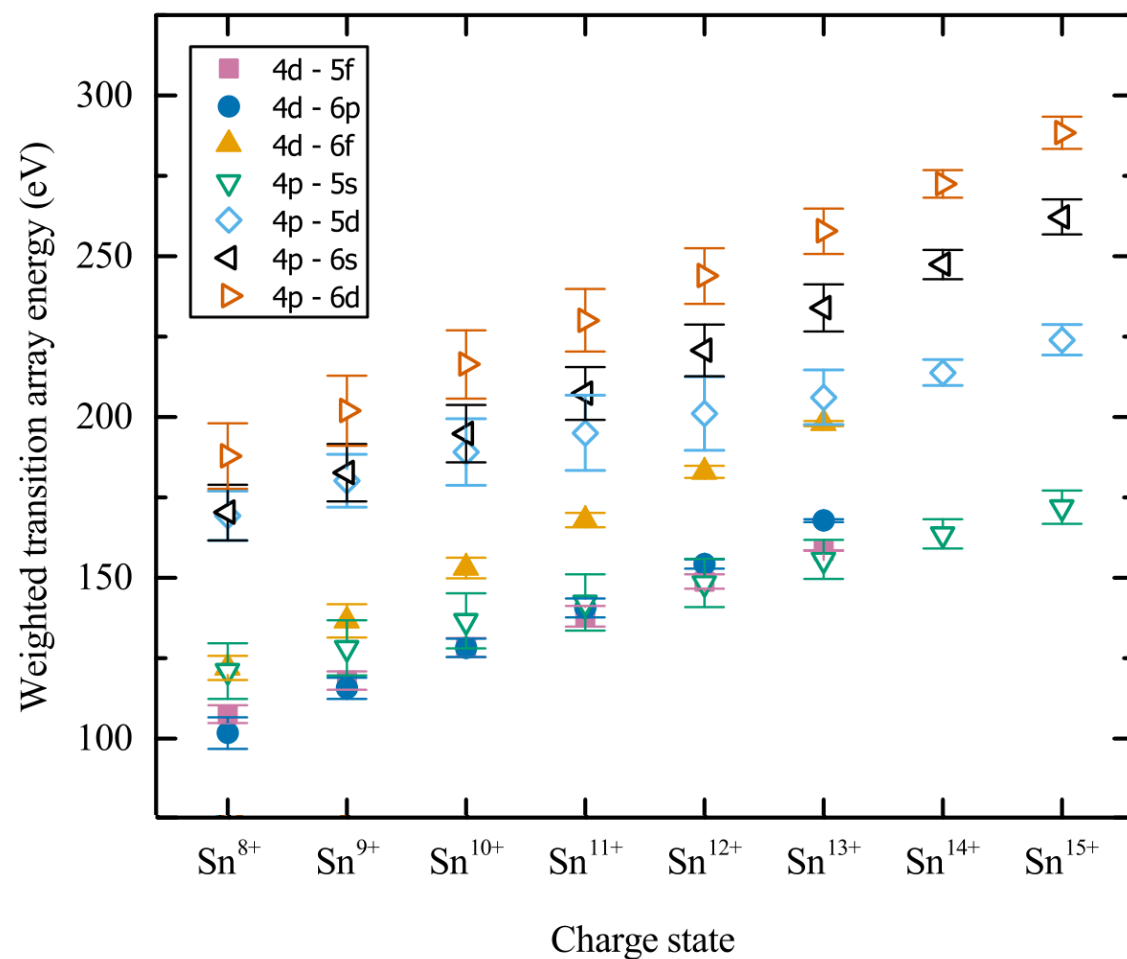






# Electric dipole transitions

Flexible Atomic Code structure calculations



F. Torretti *et al*, arXiv:1709.02626 (2017)

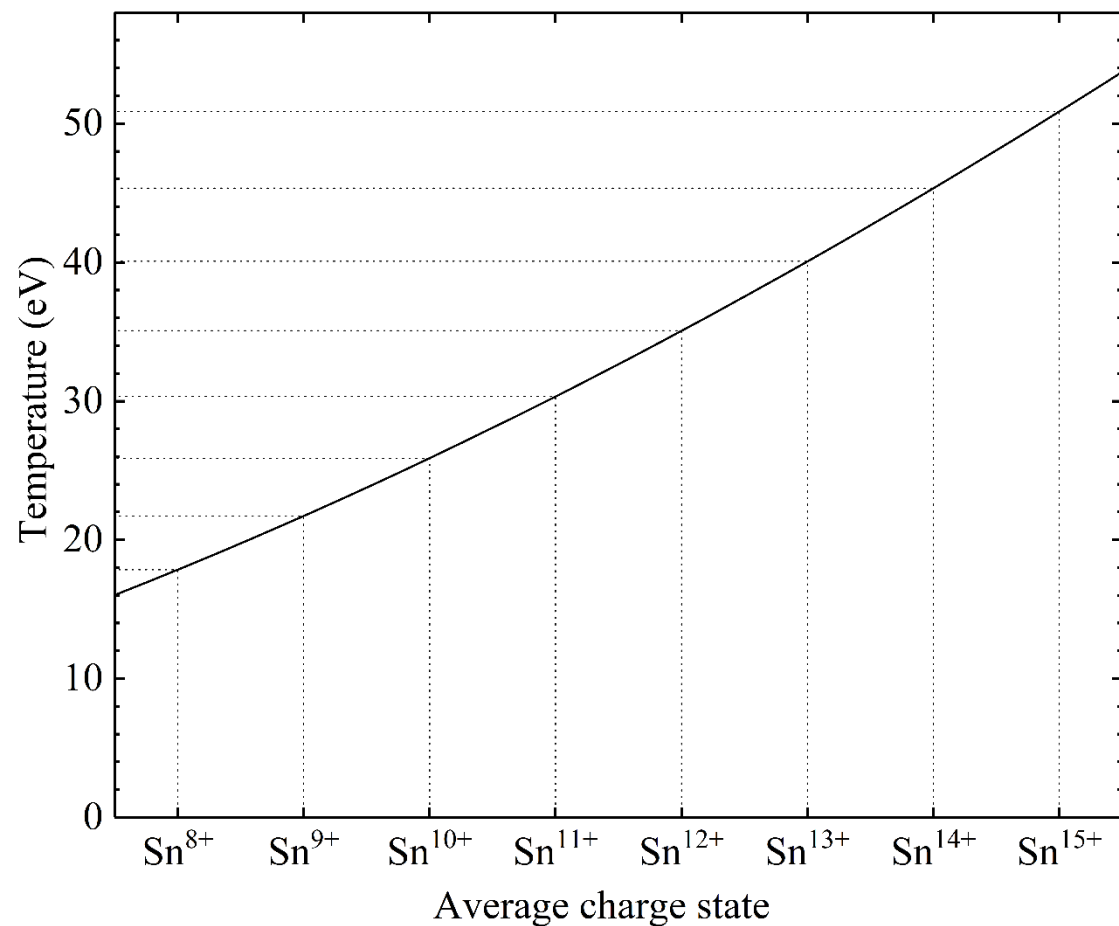


# Electric dipole transitions

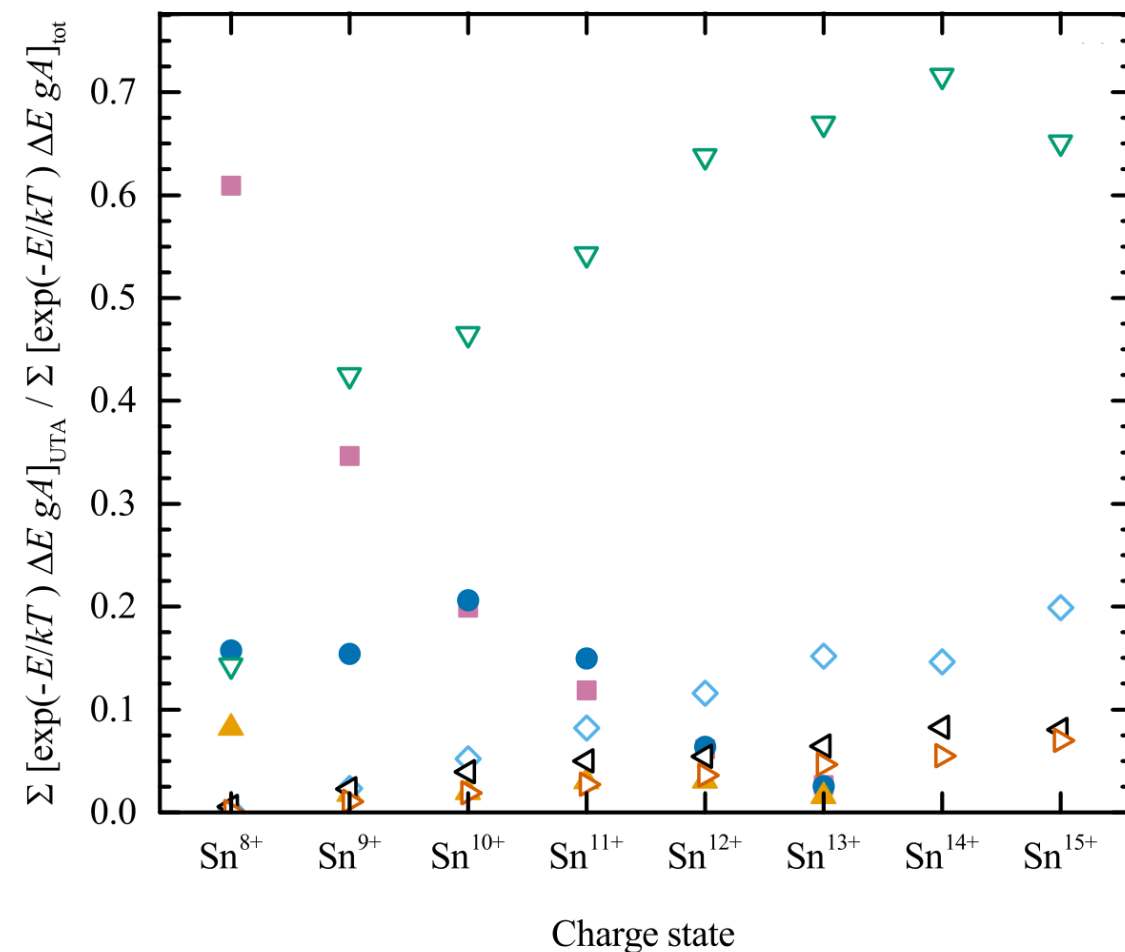
$$I_{ij} = n_i \Delta E_{ij} A_{ij} \propto \exp(-E_i/kT) \Delta E_{ij} g_i A_{ij}$$

$$kT(\text{eV}) = 0.56 \cdot \bar{Z}^{5/3}$$

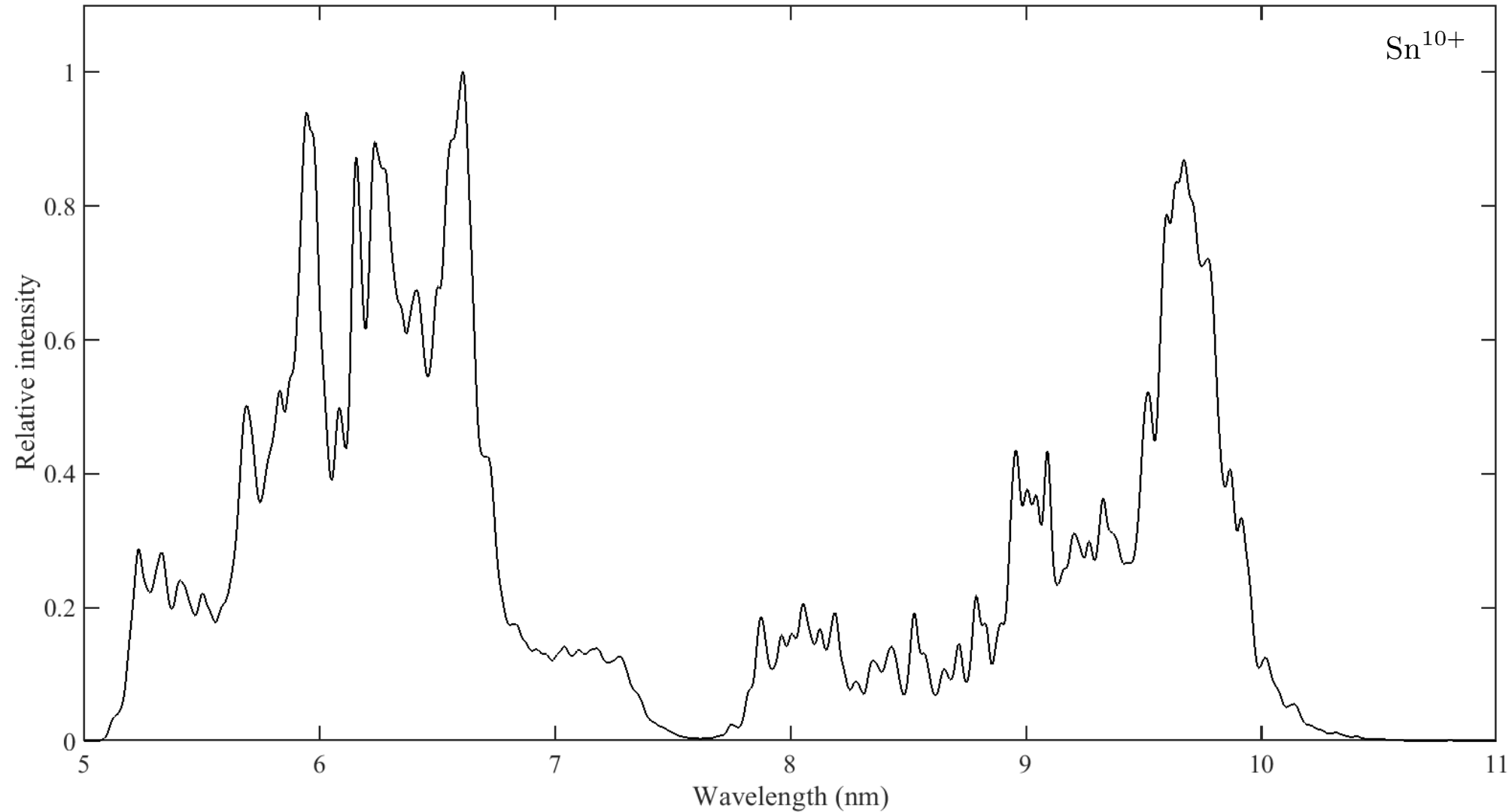
M.M. Basko *et al*, Phys. Plasmas **22**, 053111 (2015)



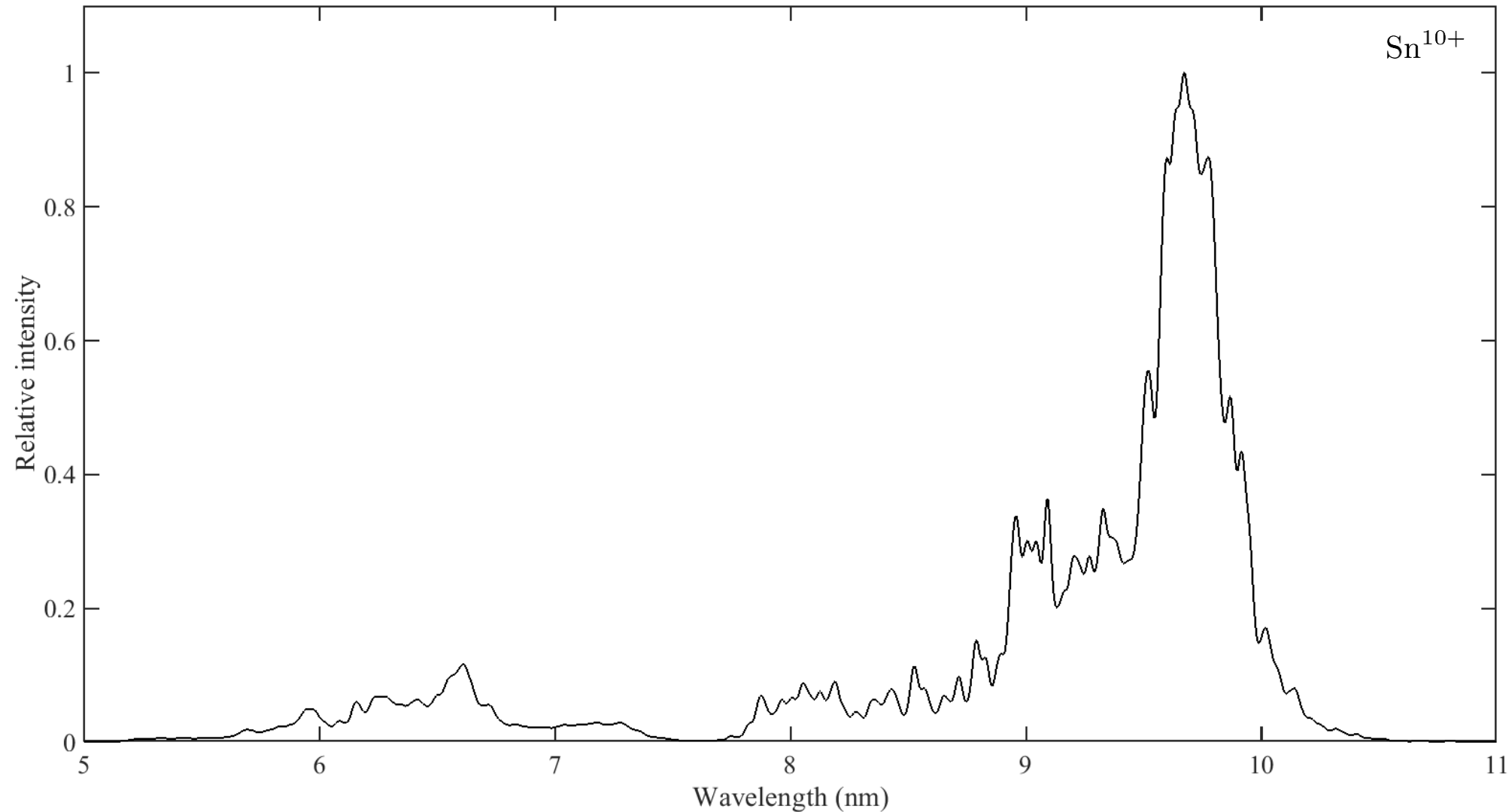
F. Torretti *et al*, arXiv:1709.02626 (2017)



Transition rates only

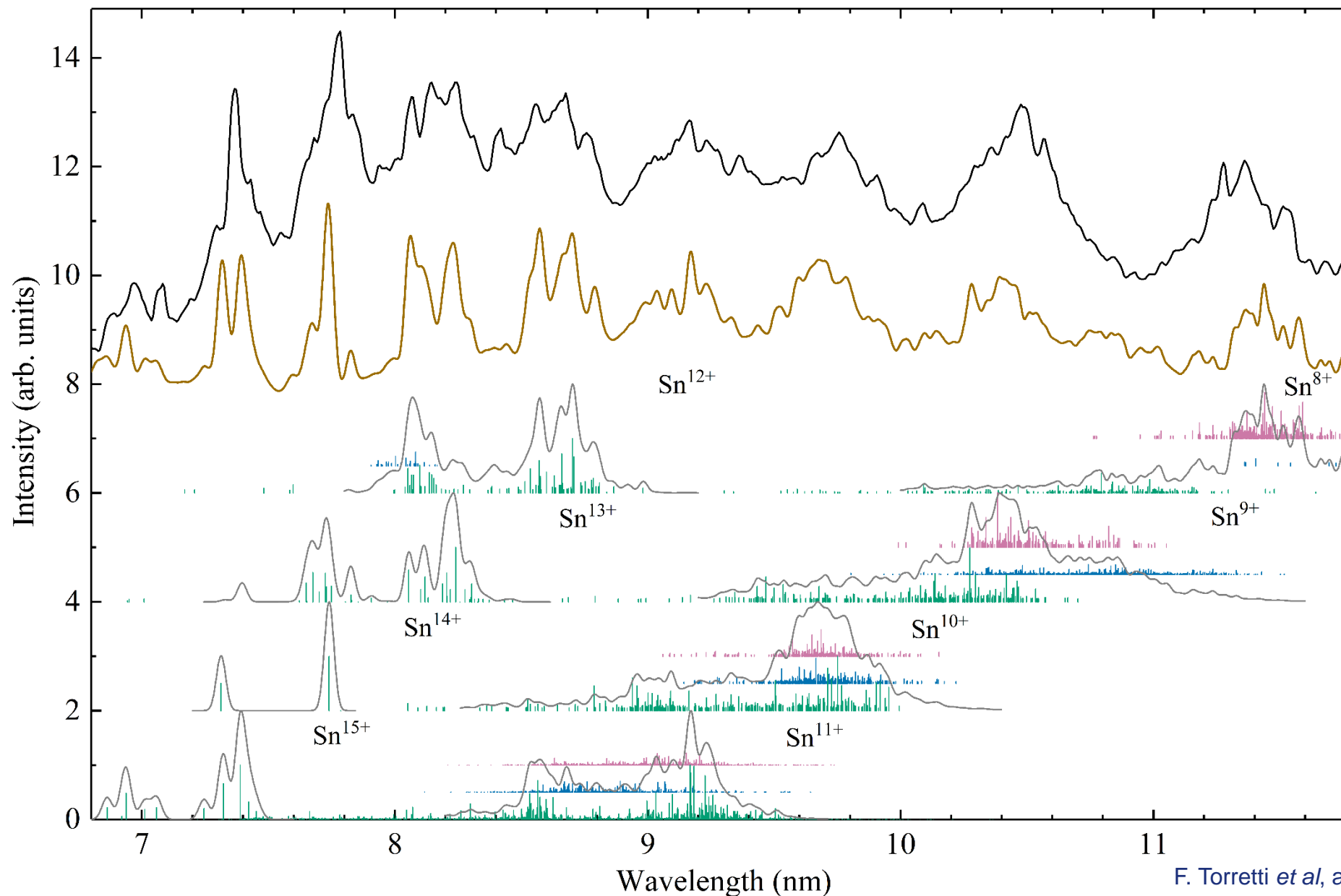


Upper level population weighted



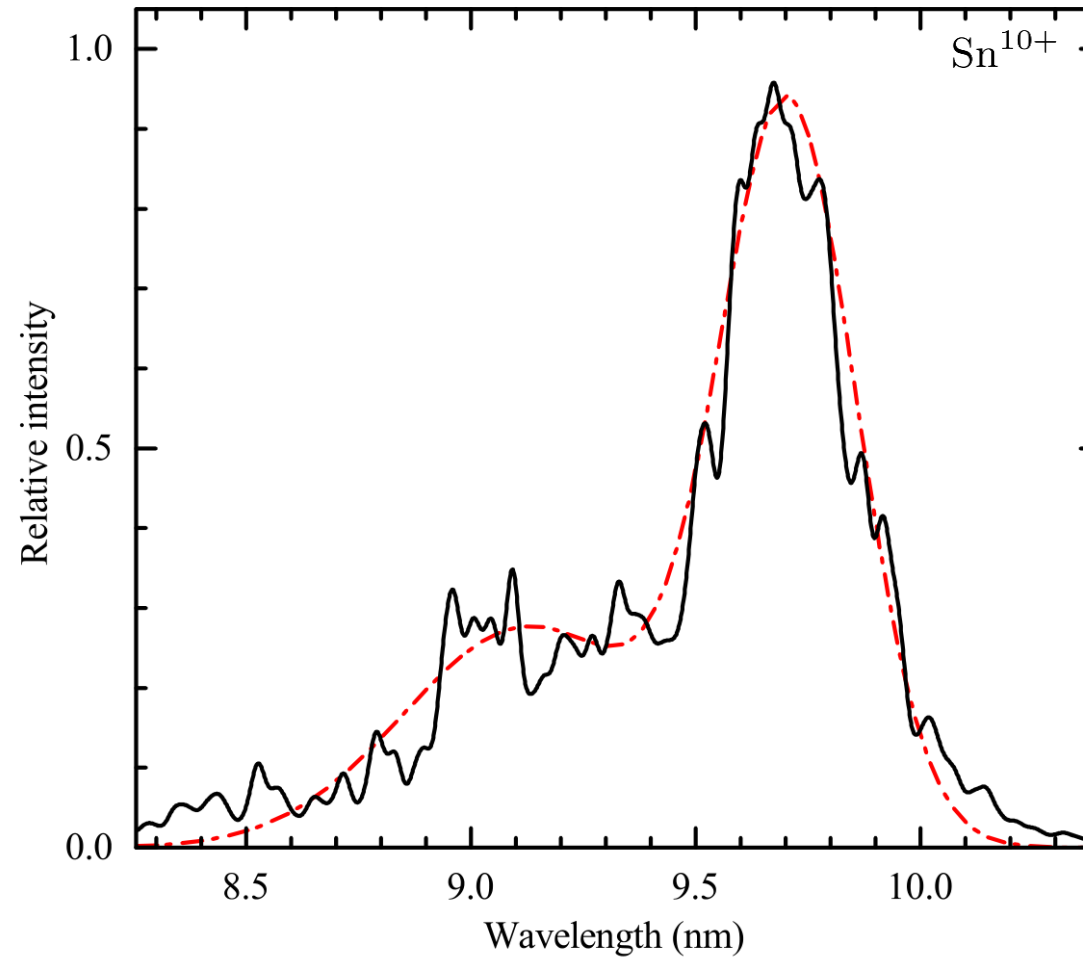


# Experiment – theory comparison



F. Torretti *et al*, arXiv:1709.02626 (2017)

## Double Gaussian fit to calculation results



F. Torretti *et al*, arXiv:1709.02626 (2017)

$$f(\lambda) = \sum_i A_i \exp \left[ -\frac{(\lambda - \lambda_{c,i})^2}{2w_i^2} \right]$$

Ion	$A_1$	$\lambda_{c,1}$ (nm)	$w_1$ (nm)	$A_2$	$\lambda_{c,2}$ (nm)	$w_2$ (nm)
Sn <sup>8+</sup>	0.232	11.433	0.088	0.127	11.578	0.610
Sn <sup>9+</sup>	0.425	10.405	0.102	0.204	10.405	0.532
Sn <sup>10+</sup>	0.274	9.127	0.276	0.911	9.706	0.152
Sn <sup>11+</sup>	0.647	8.646	0.156	1.000	9.154	0.137
Sn <sup>12+</sup>	0.745	8.100	0.086	0.826	8.650	0.127
Sn <sup>13+</sup>	0.460	7.709	0.052	0.481	8.210	0.085
Sn <sup>14+</sup>	0.138	7.313	0.019	0.273	7.740	0.019
Sn <sup>15+</sup>	0.292	6.950	0.078	0.785	7.380	0.055



ADVANCED RESEARCH CENTER FOR NANOLITHOGRAPHY

EUV Plasma Processes group



Wim  
Ubachs



Ronnie  
Hoekstra



Oscar  
Versolato



Laurens  
Van Buuren



Dmitry  
Kurilovich



Joris  
Scheers



Ruben  
Schupp



Alex  
Bayerle



Francesco  
Torretti

